

**Referee Report – Application for a Research Grant  
Rapport de l'examineur – Demande de subvention de recherche**

Please type / Veuillez dactylographier

Family name, given name and initial(s) of applicant / Nom de famille, prénom et initiale(s) du candidat		Application no. / N° de la demande
<b>Rodning, Nathan NL</b>		<b>186695</b>
PIN: 49475		
Type of grant / Type de subvention	Committee / Comité	
Subatomic Physics Envelope - Project / Enveloppe de physique subatomique - projet	<b>19</b>	
Confidence Level / Niveau de confiance		
How close is your area of expertise to that of the proposal? / Dans quelle mesure votre domaine d'expertise est-il lié à celui de la proposition?		
<input checked="" type="checkbox"/> Very close / Étroitement lié	<input type="checkbox"/> Somewhat close / Plus ou moins lié	<input type="checkbox"/> Not close / Aucunement lié

The experiment *TWIST* (TRIUMF exp.E614) aims at testing the Standard Model with unprecedented precision in a purely leptonic process of minimal theoretical uncertainties. Both the interest and the feasibility of the experiment, at its stated level of precision, were ascertained by various scientific committees and E614 can now be considered as the flagship-experiment of TRIUMF at intermediate energies.

GSC19 readily allocated funds to the start up the experiment.

This request is now for funds needed to achieve the construction and to operate E614 up to its first results. The request is corroborated by a description of the successful tests of a Pre-Production Prototype chamber and by a wealth of Monte-Carlo simulations used to freeze constructional options and to identify the points which should be tested with care in the course of the experiment. The construction is readily started and a careful flow-chart of the experiment is provided. A distribution of the responsibilities within the collaboration is also given with unusual detail and corresponds well to the various expertises of the collaborating partners. It should be stressed in this respect that quite a number of the applicants are at the highest level of excellence in their respective fields and have impressive achievements on records.

There seems to be an effort to use maximally the educational value of the experiment incorporating quite a number of Ph.D. and younger students. It should be stressed that an experiment of such an ambitious precision-aim is indeed an excellent opportunity to train highly qualified personnel.

As a conclusion, this referee strongly recommends to satisfy the bulk of the request. As he is not knowledgeable of the travel-resources the partners may have from other funds, this part of the request may have to be checked by GSC19.

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(Instructions on reverse / Instructions au verso)

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Family name, given name and initials(s) of applicant / Nom de famille, prénom et initiale(s) du candidat Rodning, L (Nathan)	Application no. / N° de la demande 186695
Type of grant / Type de subvention Subatomic Physics - Project	Committee / Comité 019

**Confidence Level / Niveau de confiance**

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This is a continuation of a previously funded project grant. It is to support the completion of experiment E614 at TRIUMF.

The investigators are experienced in muon experimentation. They have so far been very successful in constructing their experiment and preparing for physics runs. It appears that they now have the manpower and organization to complete a very challenging set of measurements on the muon decay spectrum.

The physics goals of this experiment are interesting and very challenging. It aims to improve measurements of all the Michel parameters by a factor of 10 or better. At that level, one is testing the standard model with very high precision and becoming sensitive to new physics beyond the standard model, such as right-handed interactions. It is complementary to collider experiments at Fermilab which will directly probe similar high gauge boson mass scales.

To utilize such precision measurements will require a complete calculation of the 2 loop QED radiative corrections to muon decay. According to the proposal such a study is underway. A secondary benefit of the experiment is its motivating that difficult but important 2 loop calculation. Such calculations push the state of the art in radiative corrections. Tools for carrying out such a calculation exist. Nevertheless, they are very challenging calculations.

Instrumentation for this experiment is also very challenging. In that regard it provides excellent training for students and postdocs. Furthermore, it helps advance the state of the art for muon physics. With the recent interest in muon colliders and intense muon storage rings for neutrino physics, muon experts should be in high demand.

Given the expertise this group is attaining in muon physics, I would recommend they also devote some effort to advanced R&D in other areas of muon physics such as beam cooling. With an active muon experiment and the technical expertise in muon physics, this group should be at the forefront of future muon initiatives such as the intense muon storage ring.

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This experiment is extremely good for the training of students and highly skilled technicians. It helps retain in Canada an expertise that is often lost with the demise of active laboratories. Canada should strive very hard to maintain active subatomic experiments at TRIUMF both because of their frontier physics goals and technical demands which encourage advanced technology.

The need for funding is well justified in order to complete an important experiment that Canada has already made significant investments in and to maintain the research activities of a large group and their students.

I support the requested funding level.

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Type of grant / Type de subvention <b>Subatomic Physics - Project</b>	Committee / Comité <b>019</b>

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The attempt to make an improvement of over an order of magnitude in the precision with which the Michel parameters are known is excellent science. At present, all experiments verify the V-A structure of the weak interaction. By contrast, it remains a puzzle that the early universe should have left handedness as an initial condition. At some energy, one should expect to evidence for a symmetric universe.

Around the world, there are many experiments that attempt to address this issue, e.g. at the high-energy colliding beam facilities and in low energy neutron experiments. Each has its merits, yet none has quite the general reach as this precision muon experiment.

On this basis, the TWIST experiment was approved at TRIUMF. A great deal of human effort and financial resources has gone into bringing it to the point where it is within a year of first data. TWIST has been reviewed a number of times by teams of experts and come through with high marks. Hence, there can be no question about supporting this proposal unless the team is not making progress or has uncovered some fatal flaw, and there is no way for them to succeed without the funds.

The TWIST collaboration is demonstrating excellent progress. The reports on the beam development, the PPP chamber test, the electronics, and the software studies are all high quality work. The team gets high marks for their progress.

It is harder to tell whether there may be some fatal flaw. If this report were for a comprehensive review, I would want a table that included an error budget from each contributing factor for each of the parameters. I would want to know the level the collaborators have demonstrated the size of the contribution and a comparison to what is needed. What I read was rather qualitative, i.e. statements that indicate all is as anticipated, but without quantitative numbers to see how much head-room exists. As an example, slit scattering is mentioned as a source of depolarization; I could not understand how much slit scattering they have measured or calculated and how good the number needs to be. Many more examples were evident in the reading. There were other issues not mentioned, such as the variations in chamber response as a function of positron angle of incidence that were hardly mentioned. However, this collaboration is an excellent group with a good record of accomplishment. Most issues are touched on in the proposal, and I have confidence that they are really addressing everything. Even though the proposal could have been more thorough, this shortcoming should not stand in the way of approval.

Many students and postdocs will work on TWIST before it is concluded. These type of precision experiments require a high level of training, and the young people will receive an excellent education, one that will serve the technical community well.

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